J. Agr. Sci. Tech. (2019) Vol. 21(4): 969-980

Preliminary Results about the Influence of Pruning Time and Intensity on Vegetative Growth and Fruit Yield of a Semi-Intensive Olive Orchard

E. M. Lodolini[1*], S. Polverigiani[2], T. Cioccolanti[3], A. Santinelli[4], and D. Neri[2]

ABSTRACT

The effect of extending the pruning time and reducing the pruning intensity was investigated on vegetative response and production of three Italian olive cultivars ('Raggia', 'Maurino' and 'Leccino') in central Italy. From 2009 to 2011, pruning was performed on 5-years-old olive trees in early spring (after bud break) at two intensity levels (minimal and heavy) and in late spring (after full bloom) at a heavy intensity. A control set of plants was left unpruned during the experiment. Results showed that the absence of pruning minimized water sprouts growth and initially generated the highest yield. The productive advantage offered by not pruning decreased at the third year. After 3 years of no pruning, the plants showed an excessive height, shading of the central portion of the canopy, and negligible vegetative growth, inducing an early senescence of the productive branches and necessitating the removal of a massive amount of dry material by applying a severe pruning operation (rejuvenation) at the end of the trial. The early spring minimal pruning technique led to the lowest amount of pruning material and provided a consistent increase in plant production compared to heavy pruning. Late spring pruning did not provide competitive advantages in terms of vegetative re-sprouting control nor yield compared to early pruning. This preliminary study suggests early spring minimal pruning in central Italy as the best practice to increase stability in yield and to control the vegetative growth of olive trees in semi-intensive orchards.

Keywords: cv. 'Leccino', cv. 'Maurino', cv. 'Raggia', Minimal pruning, Late pruning.

INTRODUCTION

Despite the rapid diffusion of high-density orchards (hedgerow) in flat and irrigated lands (Mateu *et al*., 2008; Tous *et al*., 2010; Russo *et al*., 2014), semi-intensive and low-density systems persist in many hilly-mountainous and rain-fed areas and represent the main cultivating systems worldwide (Duarte *et al*., 2008; Fernandez-Escobar *et al*., 2013). Nevertheless, despite the traditional set up, innovative management strategies are of great interest for semi-intensive orchards (Pergola, 2013) where the main challenges are reduced cultivation costs and control of vegetative growth and plant size without compromising plant productivity (Graaff *et al*., 2008; Farinelli *et al*., 2011; Dias *et al*., 2012; Castillo-Ruiz *et al*., 2017).

Pruning always represents a loss for the tree because it removes photosynthetically active material producing carbohydrates needed for vegetative growth and yield

[1]Council for Agricultural Research and Economics, Research Center for Olive, Citrus and Tree Fruit, Rome, Italy.

[*] Corresponding author; E-mail: enricomaria.lodolini@crea.gov.it

[2] Department of Agricultural, Food and Environmental Sciences, Marche Polytechnic University, Ancona, Italy.

[3] Inter-regional Olivicola Association of the Middle Adriatic (AIOMA), Ancona, Italy.

[4] Agri-food Sector Services Agency of the Marche (ASSAM), Osimo (AN), Italy.

[DOR: 20.1001.1.16807073.2019.21.4.4.9]

(Tombesi and Tombesi, 2007). However, pruning is necessary to maintain a good balance between vegetative and reproductive activities (Famiani *et al*., 2009), to reduce the over-shading of the inner portion of the canopy by promoting light and air penetration (Tombesi and Tombesi, 2007), to prevent the senescence of the reproductive branches through a periodical renewal of the shoots (Lodolini and Neri, 2012), to remove the non-productive wood from the canopy (Pastor and Humanes-Guillen, 2000), to stimulate metabolism and growth (Gucci and Cantini, 2000), and to control tree size and adapt the canopy to the harvest system (Tous, 2011; Fernandez-Escobar *et al*., 2013; Castillo-Ruiz *et al*., 2017).

In cold areas e.g. northern Spain and central Italy, olive trees are traditionally pruned between the end of winter and full bloom to avoid damages from frost return (Pastor and Humanes-Guillen, 2000; Famiani *et al*., 2009). Pruning in early winter is very risky because of frequent winter cold damages (Lodolini *et al*., 2016). The common technique removes a lot of material, looking for strictly geometric training systems stimulating in turn a vigorous vegetative response. Experiments conducted in different environments confirm that severe pruning may reduce total yield (Hartmann *et al*., 1960; Tombesi *et al*., 2000; Lodolini *et al*., 2011; Connor *et al*., 2014; Rodrigues *et al*., 2018), leading to strong water sprouts growth and alternate bearing. The risk to stimulate an unbalanced vegetative growth by severe canopy removal, which might potentially exacerbate alternate bearing in a short-term period, is confirmed in several studies (Monselise and Goldshmidt, 1982; Lavee, 1985; Gucci and Cantini, 2000; Tombesi *et al*., 2014). Light pruning resulted in a more rational management practice to control the canopy size and shading, while unpruned trees grew with higher, larger and denser canopy (Rodrigues *et al*., 2018).

The timing of pruning can affect vegetative response and might represent a tool to control olive trees shape while limiting unbiased growth. A delay of pruning practice near or after the full bloom could mitigate excess vegetation, resulting in a reduced water sprouts growth and a better control of canopy size, as reported for other fruit tree species (Marini and Barden, 1987; Kappel and Bouthillier, 1995; Lanzelotti *et al*., 1998; Hossain *et al*., 2004; Neri and Massetani, 2011; Lodolini *et al*., 2018). In the long term, a moderate vegetative growth might lead to a lower need for wood removal and allow a management based on minimal pruning. The restraining of canopy growth generates a different source/sink ratio reducing carbohydrate request from shoot; thus potentially interferes with fruit growth and flower bud differentiation (Smith and Samach, 2013) implementing yield production and mitigating alternate bearing (Rallo *et al*., 1994). Monselise and Goldschmidt (1982) quoting Poli (1979) stated that a very large number of flowers (from 200,000 to 400,000 per tree) require a great amount of available reserves for their full development in a phenological stage when a great number of developing vegetative apices are acting as preferential sinks.

Some authors affirm that a delay of pruning, near or after the full bloom, will remove tissues towards where nutrients and carbon reserves have already been remobilized, and can result in a net loss of resources for the plant and lead to severe alternate bearing (Gucci and Cantini, 2000; Alfei *et al*., 2002). Canopy management also influence the amount of Photosynthetically Active Radiation (PAR) intercepted by the orchard and plant potentiality for production (Villalobos *et al*., 2006). Carbohydrates production, allocation and availability determine floral induction (Samach and Smith, 2013) influencing yield and intensity of alternate bearing.

The effect of pruning technique on vegetative and reproductive response should be evaluated over at least a full ‘on’–‘off’ year cycle, since the effect of canopy

[DOR: 20.1001.1.16807073.2019.21.4.4.9]

management is cumulative over the years. The present experiment aimed to conduct a study on the influence of different pruning times and intensities on vegetative growth and yield of young productive olive trees of three different cultivars, in a semi-intensive training system in Central Italy.

MATERIALS AND METHODS

Plant Material and Experimental Design

A field study was carried out from 2009 to 2012 in a rain-fed olive orchard planted in early spring 2004 with a planting density of 237 trees ha^{-1} (6.5×6.5 m), trained as free polyconic vase and located in Central Italy (latitude 43° 56' N; longitude 13° 25' E; altitude 191 m asl). Weekly average temperatures and rainfalls of the research site during the experimental period are reported in Figure 1. Three cultivars of *Olea europaea* L., namely, 'Raggia' (locally spread cultivar), 'Maurino' and 'Leccino' (nationally spread cultivars) were tested for the effect of intensity and period of pruning on vegetative growth and plant yield.

An experiment with a two-factorial completely randomized block design with seven replicates was performed on homogeneous trees. The variables were the three olive cultivars and the pruning techniques: Early Spring Minimal (ESM) and Early Spring Heavy (ESH), Late Spring Heavy (LSH) and No Pruning (NP).

Pruning Techniques and Vegetative Growth

From 2009 to 2011, pruning was performed every year in April, after bud break, for early spring treatments, and in June, after full bloom, for late spring treatment, while unpruned trees were used as control. The minimal pruning only guided the growth following a free vase training system for canopy (light thinning of the upper portion and removal of some vigorous water sprouts in the inner part). However, the heavy pruning forced toward a regular and geometrical canopy arranged according to a strictly conical shape of each primary branch (heavy thinning in the upper portion, removal of all vegetative shoots grown in the inner part and selection of secondary branches). Pruning operations were performed using hand-held tools from the ground and average removed material was 3.7±1.9 and 10.8±3.8 kg per year for light and heavy pruning treatments, respectively.

Tree height and canopy diameter, calculated as the average of longitudinal and transversal diameters, were yearly measured in April before pruning intervention.

Trunk diameter was registered on the same date from the average of the transversal and longitudinal sections measured at 20 cm from the ground and used to calculate the Trunk-Cross Sectional Area (TCSA). The

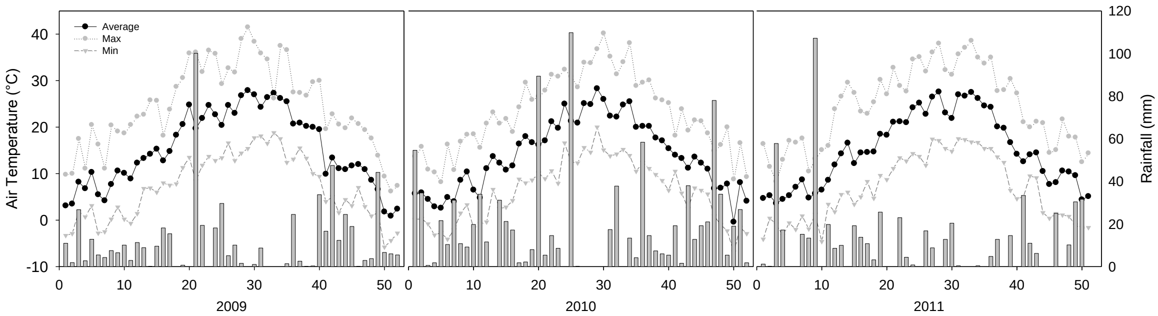

Figure 1. Weekly minimum, maximum, and average air temperatures (°C) and total precipitation (mm) from 2009 to 2011 as recorded by the weather station located at 9 km from the study site.

pruning material was collected, dried at 70°C until constant weight, and weighted. Water sprouts newly produced on the primary branches were counted in December every year.

All the above parameters were measured yearly from 2009 to 2011 and replicated on 7 trees per treatment per cultivar.

Fruit Yield and Efficiency

Total fruit yield per tree was recorded at harvest each year and expressed as fresh weight. The yield efficiency was calculated yearly and expressed as the fruit production (kg) over the Trunk-Cross Sectional Area (cm^2) according to Gucci *et al*. (2007) and Moutier *et al*. (2011). In order to check the effect of the tested pruning treatments on the fruit yield efficiency, the ratio between fresh fruit production and dry pruning material (yield to pruning mass ratio) was also calculated for each experimental year and as cumulated value for each pruning treatment (Silvestroni *et al*., 2018).

In February 2012 a dramatic freezing event took place in the region where the experiment was carried out (Lodolini *et al*., 2016) and largely reduced the fruit yield per tree so that the yield data were considered not representative for the 2012 season. In April 2012, a pruning intervention was performed, independently from the experimental treatment, in order to bring all trees to a uniform size. The pruning material was collected, dried at 70°C until constant weight and dry weighted.

Statistical Analysis

All data were tested using a two-way ANOVA focusing on the influence of pruning technique, cultivar, and year and on their cross interaction. The Tukey's (HSD) test was used for means separation whenever the ANOVA indicated a significant influence of a variable. In particular, in the presence of a significant cross interaction, the mean separation test was performed separately within all single levels of the second affecting factor. The effect of pruning time and intensity was tested by a Student's t test (α= 0.05). All statistical analyses were performed using JMP 10 (SAS Institute Inc., Cary, NC).

RESULTS

Canopy height and diameter progressively increased over the years. Canopy height differed among cultivars, whereas neither pruning time (ESH *vs* LSH P= 0.468) nor intensity (ESH *vs* ESM P= 0.140) influenced the canopy height measured each year before pruning, over the whole experiment, thus indicating a general full recovery of the tree size over the vegetative season for all treatments. Differences between each pruning treatment and the unpruned trees

Table 1. Two-Way ANOVA testing the influence of cultivar, pruning treatment, year and their cross interaction on water sprouts growth, pruning material and fruit yield.

	Plant height	Canopy diameter	Emitted water sprouts	Pruning material	Fruit yield
Cultivar	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003
Year	< 0.0001	< 0.0001	0.0010	0.0010	< 0.0001
Treatment	0.2240	0.668	< 0.0001	< 0.0001	< 0.0001
Treatment×Cultivar	0.0542	0.152	< 0.0001	< 0.0001	0.3480
Year×Treatment	0.1135	0.94	< 0.0001	< 0.0001	< 0.0001

were also generally not significant over the study period for both canopy size descriptors (Table 1). The only difference was represented by a higher tree height recorded in the unpruned trees compared to ESH exclusively in 2010 and for the cv 'Raggia' (Figure 2), where no differences were recorded in the canopy diameter (Figure 3). The same lack of influence was recorded for trunk diameter being the ANOVA p values 0.40 and 0.70 for pruning time (ESH *vs* LSH) and intensity (ESH *vs* ESM), respectively. The number of new water sprouts per tree produced on the primary branches showed significant differences among years and cultivars and a cross interaction of the pruning treatment with the above variables. Therefore, results are reported focusing on the effect of the treatment per single year (Figure 4-a) and per single cultivar (Figure 4-b) separately. The heavy pruning treatment stimulated a significant and consistent increase in water sprouts growth over the three years when compared to the minimal one (Student's t test $P< 0.0001$), as well as the early compared to the late heavy pruning treatment ($P< 0.0001$). The ESM pruning induced a water sprouts emission never different from the NP (Figure 4-a). Water sprout growth was also influenced by cultivars and a cross interaction between cultivar and pruning treatment was recorded (Table 1). The LSH treatment differed from NP only for the cultivar 'Raggia', while for ESH the stimulus offered to the vegetative growth was consistent in all cultivars (Figure 4-b). The vegetative response quantified in terms of emission of new water sprouts in the following December was always positively correlated with the amount of material removed with pruning and the strongest correlation was recorded in 2011 (Pairwise corr.= 0.71 not shown). The dry weight of the pruning material was fairly constant over the trial for ESM and LSH, while the pruning material increased for ESH, being significantly higher in 2011 than in the previous years (Figure 5-a). Late pruning reduced the total amount of material removed with pruning over the four years of experimentation compared to the early intervention (Student's t test $P< 0.0001$), as well as the minimal pruning compared to the heavy one ($P< 0.0001$). The pruning of all dry/exhausted branches for NP treatment at the end of the trial (April 2012) removed 57.7±8.8, 60.3±6.5 and 63.7±4.8 kg of dry material in 'Raggia', 'Maurino' and 'Leccino' cultivars, respectively. These amounts were largely higher than the total pruning material removed over the four years in each of the other pruning treatments (Figure 5-b).

Fruit yield per tree was largely variable among years and differences due to the pruning treatment were influenced by the annual variation in crop load. Minor differences were recorded due to cultivar (Table 1). The highest cumulative fruit yield was registered for NP trees. In particular, the NP control induced a higher fruit yield in the first two years. The year 2011 showed a relatively high production for pruned trees (all treatments), whereas the NP control trees decreased the fruit yield from 2010 to 2011 so that no differences on fruit yield per tree were recorded in 2011 due to the applied pruning treatment (Figure 6-a). The heavy pruning induced the lowest fruit yield in 2009 and 2010, especially when applied in early spring, and registering the lowest cumulative fruit production over the experimental period (Figure 6-b). Yield efficiency data confirmed the 2009 and 2011 as 'off' years and indicated the lack of differences due to the applied pruning treatments (Figure 7).

When the pruning efficiency in terms of yield to pruning mass ratio was considered, early spring minimal treatment showed significantly higher values per year (Figure 8-a) and for the whole experimental period (Figure 8-b) when compared to the other pruning treatments and control trees. As reported in Figure 6-b, late spring heavy treatment showed the same pruning efficiency as no pruning (0.86 and 0.87, respectively), whereas early spring heavy treatment strongly reduced it when

[DOR: 20.1001.1.16807073.2019.21.4.4.9]

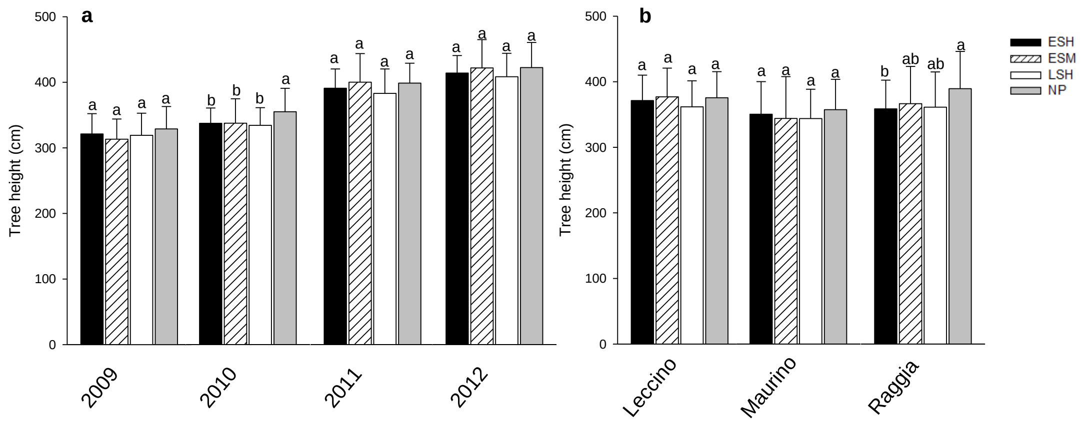

Figure 2. Tree height measured on single year (a) and single cultivar (b) for each pruning treatment: Early Spring Heavy (ESH), Early Spring Minimal (ESM), Late Spring Heavy (LSH), No Pruning (NP). Columns represent means + standard deviation of 21 replicates. In the same year (a) or for the same cultivar (b), different letters indicate significant differences between treatments according to the Tukey (HSD) test *P*< 0.05.

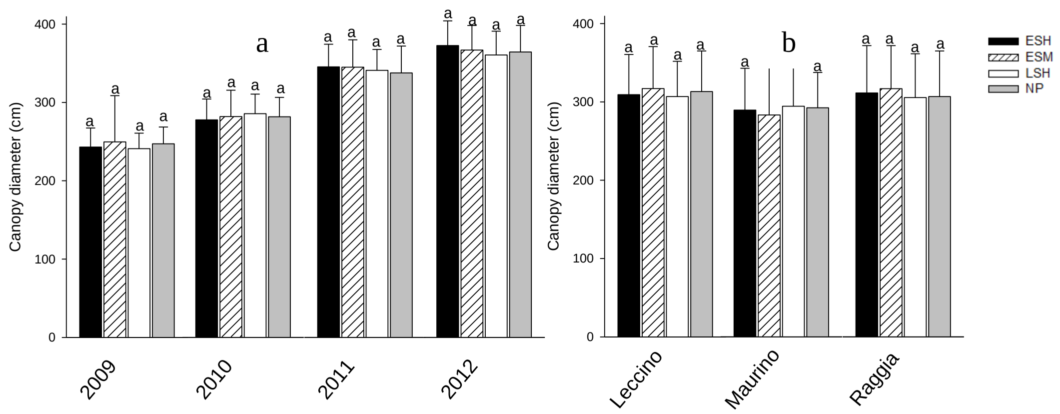

Figure 3. Canopy diameter measured on single year (a) and single cultivar (b) for each pruning treatment. Symbols are as defined in Figure 2. Columns represent means+standard deviation of 21 replicates. Different letters indicate significant differences between treatments according to the Tukey (HSD) test *P*< 0.05.

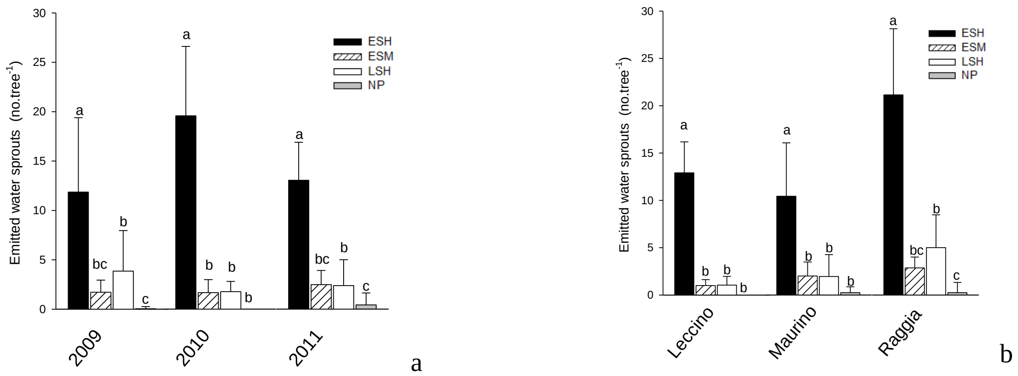

Figure 4. Number of new water sprouts per tree emitted on each year (a) and on each cultivar (b) for each pruning treatment. Symbols are as defined in Figure 2. Columns represent means+standard deviation of 21 replicates. Different letters indicate significant differences between treatments according to the Tukey (HSD) test P< 0.05.

[DOR: 20.1001.1.16807073.2019.21.4.4.9]

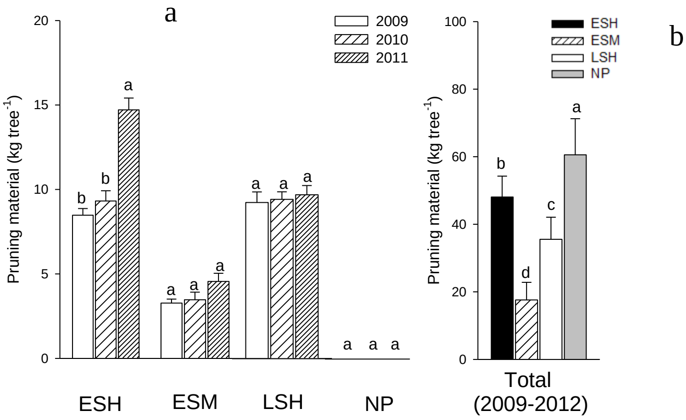

Figure 5. Pruning material (dry weight) removed each year from 2009 to 2011 and for each pruning treatment: Symbols are as defined in Figure 2. In the same pruning treatment, years labeled with different letters significantly differ according to the Tukey (HSD) test P< 0.05 (a). Cumulative pruning material (dry weight) removed over the trial (b). Columns represent means+standard deviation of 21 replicates. Different letters indicate significant differences between treatments according to the Tukey (HSD) test *P*< 0.05 (b).

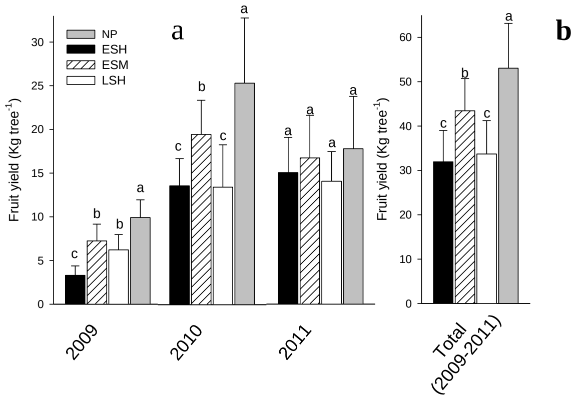

Figure 6. Fruit yield per tree in each single year of experimentation (a) and for each pruning treatment (b). Symbols are as defined in Figure 2, and cumulated fruit production over the three years of the experiment. Columns represent means+standard deviation of 21 replicates. Different letters indicate significant differences between treatments according to Tukey (HSD) test *P*< 0.05.

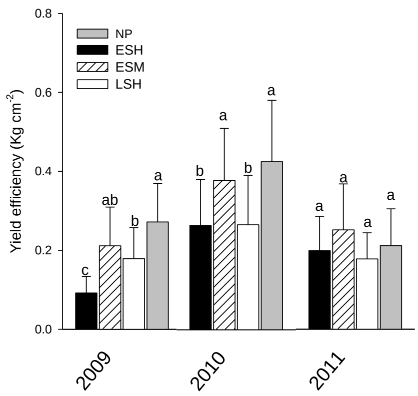

Figure 7. Yield efficiency expressed as fruit production over Trunk-Cross Sectional Area (Kg cm^{-2}) in each single year of experimentation on each pruning treatment**.** Symbols are as defined in Figure 2. Columns represent means+standard deviation of 21 replicates. Different letters indicate significant differences between treatments according to Tukey (HSD) test *P*< 0.05.

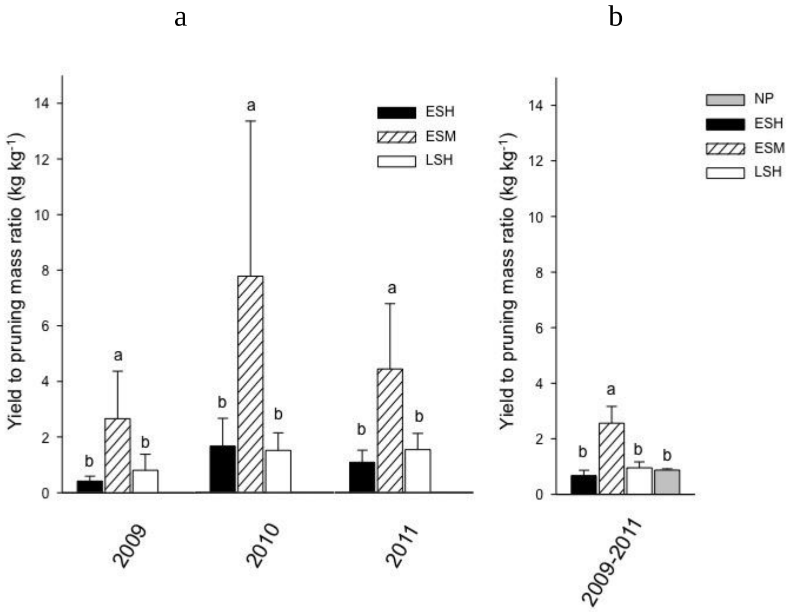

Figure 8. Yield to pruning mass ratio efficiency (kg.kg^{-1}) in each single year of experimentation (a) and for each pruning treatment (b). Symbols are as defined in Figure 2, and cumulated fruit production over the three years of the experiment. Columns represent means+standard deviation of 21 replicates. Different letters indicate significant differences between treatments according to Tukey (HSD) test *P*< 0.05.

compared to early spring minimal pruning (0.68 and 2.33, respectively).

DISCUSSION

In the present study, a heavy pruning in early spring led to the lowest cumulative fruit yield on young productive olive trees. The reduction of the fruit yield per tree when severely pruned was consistent in all cultivars. Differences were magnified during highly productive years as previously found by Castillo-Llanque *et al*. (2008) and Lavee *et al*. (2012). Moreover, a strong water sprouts growth on the primary branches was stimulated after early spring heavy pruning (from 10 to 20 new water sprouts per tree per year), leading to the removal of and increasing amount of material over the years. On the contrary, late spring heavy pruning induced the growth of a very few number of new water sprouts (below 5 per tree per year), which can be considered comparable to early spring minimal and no pruning.

The three-years' experience demonstrated how minimal pruning in April can be suggested to control vegetative growth and canopy size, even maintaining a good fruit set and yield. Late spring heavy pruning (after blooming) acted in reducing the vigor of the trees when compared to early spring heavy treatment, showing similar yields and confirming the effect of controlling vegetative growth without affecting fruit production for late interventions. The unpruned trees had the highest fruit yields during the three years of the experimentation, but at the end of the trial, the canopy showed an excessive shading of the central portion and a general ageing (senescence) of the productive branches. This led to an overall collapse and thus requiring a drastic pruning intervention (rejuvenation) at the fourth year to stimulate the vegetative growth and recover the vegetative-reproductive balance of the canopy in the following seasons, thus avoiding tree senescence. Furthermore, the initial advantages in fruit yield offered by the NP control disappeared in the third year.

The NP control was the only treatment showing a significant decrease of productivity from 2010 to 2011 despite the persisting of a lower source/sink competition with the shoot, having significantly lower water sprouts growth. The cause of the decrease in the production can be indicated as the shading that potentially compromises flower formation and thus plant productivity (Proietti and Tombesi, 1996; Tombesi *et al*., 1999). Pastor and Humanes-Guillen (2000) confirmed a threshold of 4 years of not pruning, indicating a significant decline of total production on adult olive trees over that period.

This preliminary study suggests minimal pruning in early spring as the most suitable annual practice for maintaining a good vegetative-reproductive balance on young productive olive trees in cold climatic conditions (i.e. central Italy).

When pruning intensity increases in early spring, vigorous vegetative re-sprouting is stimulated and fruit production decreases due to both excessive removal of fruiting shoot and mobilization of resources to water sprouts on primary branches instead of going to mixed shoot growth, leading to a general lesser pruning efficiency (kg of fruit produced per kg of pruning material removed).

Postponing pruning after full bloom on rain-fed trees reduces vigorous re-sprouting at the same level of minimal pruning in early spring, but the production is comparable to the trees heavily pruned in early spring. The intensity of late spring pruning should be reduced in order to prevent compromising fruit production level with excessive leaf removal.

Reducing pruning interventions is possible on olive and the combination of reducing costs and increasing pruning efficiency appears an interesting management option, especially in young productive olive trees with increasing canopy volume. Nevertheless, our study indicates a 3-year period as the threshold for not pruning in order to avoid a premature canopy and fruit production decline and suggests a triennial pruning as the maximum suitable turn for rain-fed semi-intensive olive orchards in central Italy.

Further studies in long-term trials and on adult trees are required to confirm results presented in this study and to investigate the effect of pruning time and intensity on olive orchards with increasing density.

REFERENCES

1. Alfei, B. and Pannelli, G. 2002. *Guida Alla Razionale Coltivazione dell'Olivo*. Pubblicazioni Assam.
2. Castillo-Llanque, F. J., Rapoport, H. F. and Navarro, C. 2008. Interaction between Shoot Growth and Reproductive Behavior in Olive Trees. *Acta Hortic.*, **791:** 453-457.
3. Castillo-Ruiz, F. J., Sola-Guirado, R. R., Castro-Garcia, S., Gonzalez-Sanchez, E. J., Colmenero-Martinez, J. T. and Blanco-Roldan, G. L. 2017. Pruning Systems to Adapt Traditional Olive Orchards to New Integral Harvesters. *Sci. Hortic.*, **220:** 122-129.
4. Connor, D. J., Gómez-del-Campo, M., Rousseaux, M. C. and Searles, P. S. 2014. Structure, Management and Productivity of Hedgerow Olive Orchards: A review. *Sci Hortic.*, **169:** 71–93 doi:10.1016/j.scienta.2014.02.010
5. de Graaff, J., Duran Zuazo, V. H., Jones, N. and Fleskensa, L. 2008. Olive Production Systems on Sloping Land: Prospects and Scenarios. *J. Environ. Manage.*, **89:** 129–139.
6. Dias, A. B., Peca, J. O. and Pinheiro, A. 2012. Long-Term Evaluation of the Influence of Mechanical Pruning on Olive Growing. *Agron. J.*, **104:** 22-25.
7. Duarte, F., Jones, N. and Fleskens, L. 2008. Traditional Olive Orchards on Sloping Lands: Sustainability or Abandonment? *J. Environ. Manage.*, **89:** 86-98.
8. Famiani, F., Proietti, P., Lodolini, E. M. and Neri, D. 2009. Gestione della Chioma (Canopy Management). In: "*Ulivo e Olio*", (Ed.): Coltura e Cultura. Milano, PP. 390-411.
9. Farinelli, D., Onorati, L., Ruffolo, M. and Tombesi, A. 2011. Mechanical Pruning of Adult Olive Trees and Influence on Yield

and on Efficiency of Mechanical Harvesting. *Acta Hortic.,* **924:** 203-209.
10. Fernandez-Escobar, R., de la Rosa, R., Leon, L., Gomez, J.A., Testi, L., Orgaz, F., Gil-Ribes, J.A., Quesada-Moraga, E., Trapero, A. and Masallem, M. 2013. Evolution and Sustainability of the Olive Production Systems. *Options Mediterraneennes*, **106:** 11-42.
11. Gucci, R., Cantini, C., 2000. *Pruning and training systems for modern olive growing*. Landlinks Press, Csiro Publishing, 144 PP.
12. Gucci, R., Lodolini, E. M. and Rapoport, H. F., 2007. Productivity of Olive Trees with Different Water Status and Crop Load. *J. Hortic. Sci. Biotech.*, **82(4):** 648-656.
13. Hartmann, H. T., Opitz, K. V. and Bentel, J. A. 1960. La Taille des Oliviers en California. *Informations Oleicoles Internationales,* **11:** 33-67.
14. Hossain, A. B. M. S., Mizutani, F. and Onguso J. M. 2004. Effects of Summer Pruning on Maintaining the Shape of Slender Spindle Bush of Peach Tree Grafted on Vigorous Rootstock. *J. Japn. Soc. Agric. Tech. Manag.,* **11:** 55-62.
15. Kappel F. and Bouthillier M., 1995. Rootstock, Severity of Dormant Pruning, and Summer Pruning in Uences on Peach Tree Size, Yield, and Fruit Quality. *Can. J. Plant Sci*., **75(2):** 491-496.
16. Lanzelotti, J., Gonzalez, B. A. and Boragno, O. A.1998. Different Dates of Pruning in Peach Tree. *Acta Hortic.,* **465:** 629-635.
17. Lavee, S. 1985. *Olea europea.* In: "*CRC handbook of Flowering*", (Ed.): Halevy, A. H. CRC Press, Boca Raton, Fla, PP. 423–434.
18. Lavee, S., Haskal, A. and Avidan, B. 2012. The Effect of Planting Distances and Tree Shape on Yield and Harvest Efficiency of cv. Manzanillo Table Olives. *Sci. Hortic.*, **142:** 166–173.
19. Lodolini, E. M., Endeshaw, T. S., Gangatharan, R., Santinelli, A. and Neri, D. 2011. Olive Fruit set in Central Italy in Response to Different Pruning Systems. *Acta Hortic.*, **924:** 195-201.
20. Lodolini, E. M. and Neri, D. 2012. How Growth and Reproduction Cycles Affect Alternate Bearing in Olive. *Acta Hortic.,* **949:** 191-198.
21. Lodolini, E. M., Alfei, B., Santinelli, A., Cioccolanti, T., Polverigiani, S. and Neri, D. 2016. Frost Tolerance of 24 Olive Cultivars and Subsequent Vegetative Re-sprouting as Indication of Recovery Ability. *Sci. Hortic.,* **211:** 152-157.
22. Lodolini, E. M., Polverigiani, S., Grossetti, D. and Neri, D., 2018. Pruning Management in a High-Density Olive Orchard. *Acta Hortic.*, **1199:** 385-390.
23. Marini, R. P. and Barden, J. A. 1987. Summer Pruning of Apple and Peach Trees. *Hortic. Rev.,* **9:** 351-375.
24. Mateu, J. C., Garcia, R. X. and Peña, J.M.L. 2008. Evoluzione Della Superficie Piantata a Oivi con il Sistema Superintensivo o a Cespuglio nel Mondo. *Olint*, **15:** 1-7.
25. Monselise, S. P. and Goldschmidt, E. E. 1982. Alternate Bearing in Fruit Trees. *Hortic. Rev*., **4:** 128–173.
26. Moutier, N., Ricard, J. M. and Le Verge, S. 2011. Vigour Control of the Olive Tree in a High Density Planting System: Two Experiment Approaches. *Acta Hortic.*, **924:** 185-193.
27. Neri, D. and Massetani, F. 2011. Spring and Summer Pruning in Apricot and Peach Orchards. *Adv. Hort. Sci.,* **25(3):** 170-178.
28. Pastor, M. and Humanes-Guillen, J. 2000. *Poda del Olivo. Moderna Olivicultura.* Editorial Agricola Espanola, SA, 374 PP.
29. Pergola, M., Favia, M., Palese, A.M., Perretti B., Xiloyannis, C. and Celano, G. 2013. Alternative Management for Olive Orchards Grown in Semi-Arid Environments: An Energy, Economic and Environmental Analysis. *Sci. Hortic.,* **162:** 380–386.
30. Poli, M. 1979. Etude Bibliographique de Ia Physiologie de L'alternance de Production chez L'olivier (*Olea europaea* L.). *Fruits,* **34:** 687-694.
31. Proietti, P. and Tombesi, A. 1996 Translocation of Assimilates and Source-Sink Influences on Productive Characteristics of the Olive Tree. *Adv. Hort. Sci.*, **10:** 11-14.
32. Rallo, L., Torreno, P., Vargas A. and Alvarado J., 1994. Dormancy and Alternate Bearing in Olive. *Acta Hortic.*, **356:** 127-134.
33. Rodrigues, M. A., Lopes, J. I., Ferreira, I. Q. and Arrobas, M. 2018. Olive Tree Response to the Severity of Pruning. *Turk. J. Agric. For.,* **42:** 103-113.

34. Russo, G., Vivaldi, G.A., De Gennaro, B., Camposeo, S., 2014. Environmental Sustainability of Different Soil Management Techniques in High-Density Olive Ochards. *J. Clean. Prod.,* **107:** 498-508.
35. Samach, A. and Smith, H. M. 2013 Constraints to Obtaining Consistent Annual Yields in Perennials. II: Environment and Fruit Load Affect Induction of Flowering. *Plant Sci.*, **207:** 168– 176.
36. Silvestroni, O., Lanari, V., Lattanzi, T. and Palliotti, A., 2018. Delaying Winter Pruning, after Pre-Pruning, Alters Budburst, Leaf Area, Photosynthesis, Yield and Berry Composition in Sangiovese (*Vitis vinifera* L.). *Aust. J. Grape Wine R.*, **24(4)**: 478-486. doi: 10.1111/ajgw.12361.
37. Smith, H. M. and Samach, A. 2013. Constraints to Obtaining Consistent Annual Yields in Perennial Tree Crops. I. Heavy Fruit Load Dominates Over Vegetative Growth. *Plant Sci.***, 207:** 158–167.
38. Tombesi, A., Boco, M. and Pilli, M. 1999. Influence of Light Exposure on Olive Fruit Growth and Composition. *Acta Hortic.*, **474:** 255–258.
39. Tombesi, A., Boco, M., Pilli, M. and Farinelli D. 2000. Influence of Canopy Density on Efficiency of Trunk Shaker on Olive Mechanical Harvesting. *Acta Hortic.,* **586:** 291-294.
40. Tombesi, A. and Tombesi, S. 2007. Olive Pruning and Training. In: "*Production Techniques in Olive Growing".* International Olive Council, Madrid, Spain.
41. Tombesi ,S., Farinelli, D., Molfese, M., Cipolletti, M. and Visco, T. 2014. Pruning Technique in Young High Density Hedgerow Olive Orchards. *Acta Hortic.*, **1057:** 385-390.
42. Tous, J., Romero, A. and Hermoso, J. F. 2010. New Trends in Olive Orchard Design for Continuous Mechanical Harvesting. *Adv. Hort. Sci*., **24(1):** 43-52.
43. Tous, J. 2011. Olive Production Systems and Mechanization. *Acta Hotic.,* **924:** 169-184.
44. Villalobos, F. J., Testi, L., Hidalgo, J., Pastor, M. and Orgaz, F. 2006. Modelling Potential Growth and Yield of Olive (*Olea europea* L.) Canopies. *Eur. J. Agron.*, **24:** 296–303.

نتایج اولیه در مورد اثر زمان و شدت هرس روی رشد سبزینه و عملکرد میوه در یک باغ نیمه متراکم زیتون

ا. م. لودولینی، س. پولوریجیانی، ت. سیوکولانتی، ا. سانتینلی، و د. نری

چکیده

در این پژوهش، اثر طولانی کردن زمان هرس و کاهش شدت هرس روی واکنش رشد سبزینه و تولید سه کولتیوار زیتون ایتالیایی (به نام های 'Raggia'، 'Maurino'، و 'Leccino') در بخش های مرکزی ایتالیا بررسی شد. به این منظور، از سال ۲۰۰۹ تا ۲۰۱۱، روی درختان ۵ ساله زیتون در اوایل بهار(بعد ازشکفتن جوانه ها) با دو شدت مختلف هرس (در حد کمینه و سنگین) و نیز در اواخر بهار (بعد از گل نشستن کامل) یک هرس سنگین انجام شد. همچنین، در طی آزمایش، تعداد ی درخت بدون هرس به عنوان شاهد در نظر گرفته شد. نتایج نشان داد که هرس نکردن باعث کمینه شدن رشد نَرَک (water sprout) شد و درختان در مراحل اول بیشترین عملکرد را تولید کردند. این امتیاز عملکردی هرس نکردن در سال سوم کم شد. بعد از ۳ سال هرس نکردن، درختان رشد زیادی در طول نشان دادند

و بر بخش های مرکزی سایه سار(canopy)سایه اندازی داشتند، و باعث رشد کم سبزینه شدند و در نتیجه پیری زودرس(early senescence) شاخه های بارور را القا کردند. این موارد منجر به این شد که در آخر آزمایش، انجام هرس سنگین برای برداشتن مقدار زیادی از شاخساره(به منظور جوان سازی rejuvenation) ضروری شود. روش هرس کمینه در اوایل بهار موجب کمترین مقدار هرس شاخساره شد و در مقایسه با هرس سنگین، افزایشی پیوسته در عملکرد محصول ایجاد کرد. هرس اواخر بهار در مقایسه با هرس اوایل بهار، از نظر رشدسبزینه و کنترل نـَرَک و یاعملکرد ارجحیت های رقابتی نداشت. این پژوهش اولیه چنین اشاره دارد که در بخش های مرکزی ایتالیا، هرس کمینه در اوایل بهار بهترین عملیات برای افزایش پایداری عملکرد و کنترل رشد سبزینه درختان زیتون در باغ های نیمه متراکم است.

[DOR: 20.1001.1.16807073.2019.21.4.4.9]